Cholera Outbreaks:
Impact, Prevention, Control

Dr P.K. Bardhan

International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)
Cholera is one of the oldest diseases with pandemic potential.

The world experienced seven cholera pandemics in the last 194 years.

In 1817, the violent epidemic that started here was the first of the seven cholera pandemics.
## Cholera Pandemics since 1817

<table>
<thead>
<tr>
<th>No.</th>
<th>Yrs</th>
<th>Origin</th>
<th>Pandemic organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1817–1823</td>
<td>India</td>
<td>Unknown</td>
</tr>
<tr>
<td>2</td>
<td>1829–1851</td>
<td>India</td>
<td>Unknown</td>
</tr>
<tr>
<td>3</td>
<td>1852–1859</td>
<td>India</td>
<td>Unknown</td>
</tr>
<tr>
<td>4</td>
<td>1863–1879</td>
<td>India</td>
<td>Unknown</td>
</tr>
<tr>
<td>5</td>
<td>1881–1896</td>
<td>India</td>
<td><em>V. cholerae</em> O1, classical biotype</td>
</tr>
<tr>
<td>6</td>
<td>1899–1923</td>
<td>India</td>
<td><em>V. cholerae</em> O1, classical biotype</td>
</tr>
<tr>
<td>7</td>
<td>1961–present</td>
<td>Sulawesi, Indonesia</td>
<td><em>V. cholerae</em> O1, El Tor</td>
</tr>
</tbody>
</table>
Spread of the 7\textsuperscript{th} cholera pandemic
Despite the advances made in understanding the disease and its treatment, cholera continues to be a major public health problem in many countries.

In its epidemic form the case fatality rate can be as high as >30%, unless the disease is diagnosed and treated by the health professionals as early as possible.
Cholera

- Cholera is a diarrhoeal disease caused by the bacterium *Vibrio cholerae*.

- 10-20% of cholera patients develop severe watery diarrhea with vomiting.

- Outbreaks can occur where water supply, sanitation, food safety and hygiene are inadequate.
Greater risks occur in over-populated communities and refugee camps, with
- Poor sanitation,
- Unsafe drinking water,
- Increased person to-person transmission.

Because incubation period is very short, the number of cases can rise extremely rapidly.

Treatment is straightforward (basically rehydration), and if applied correctly and promptly, case fatality rate is <1%.

In untreated cases, case fatality rate may reach 30-50%.
Transmission of Cholera

* Transmitted by the fecal-oral route.
* Contaminated food (especially seafood) is a more common cause of cholera in developed countries, whereas contaminated water is more common in developing countries.
* 88% of all diarrheal disease in the world can be attributed to unsafe water, sanitation and hygiene.
Cholera occurs worldwide

Country with cholera cases – Pays avec des cas de choléra
Imported cholera cases – Cas de choléra importés

2001
Fig. 4.1 Cholera, reported number of cases and case fatality rates, 1950-1998

Cholera cases reported to WHO by year and by continent 1989-2009
Impact of Cholera Outbreaks

Public Health systems

- Number of ill persons
- Deaths
- Health personnel
- Treatment infrastructure
- Medicines and other supplies

National Economy

- Direct costs
- Wage loss
- Industrial and Agricultural production
- Trade and Exports
- Travel and Tourism

Political
The Impact of Cholera

PERU
Peru at a Glance (1990)

• 60% of population (7 million) living in poverty
• 14% living in extreme poverty
• Urban population 71%
• 10% without adequate water or sanitation
• In Lima, 7 million serviced by water supply designed for 230,000
• Existing supplies overstretched leading to sewage contamination
Cholera in Peru

Reported January 1991
12,000 cases by mid-February
Spread to neighbouring countries by March
End of 1991: 400,000 cases, 4,000 deaths
Consequences of the Epidemic

- Ill fated Health Minister
- Border closures
- Tourist Industry lost $150 million (1991)
- Shrimp exports declined $270 million
- Overall loses at $770 million
- For countries already struggling to provide basic public health, outbreaks further undermine capacity of governments to address underlying causes of epidemic in long term.
Prevention and Control

**Blocking Transmission:**
- Environmental Control
- Water Supply
- Sanitation / Sewage Disposal
- Personal Hygiene
- Food Safety

**Containment:**
- Surveillance
- Early Detection
- Prompt management
- Following up contacts / family members
- Disinfection / Funeral precautions

**Case-management**

**Vaccination**
The potential impact of environmental control methods.

<table>
<thead>
<tr>
<th>Disease category</th>
<th>Personal hygiene</th>
<th>Cooking of foods</th>
<th>Water supplies</th>
<th>Sanitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water-washed diseases</td>
<td>+++</td>
<td>-</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>2. Faecal-oral diseases</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>3. Soil-mediated diseases</td>
<td>++</td>
<td>+++</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>4. Water-based diseases</td>
<td>-</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>5. Water- and excreta-related insect vectors</td>
<td>-</td>
<td>-</td>
<td>±±</td>
<td>±±</td>
</tr>
</tbody>
</table>

+++ Very effective; ++, moderately effective; +, effective; -, not effective; ±, can be either effective or not effective.

1: Skin diseases, conjunctivitis
2: Diarrhoea, typhoid, Hepatitis A
3: Intestinal helminths
4: Schistosomiasis, Fasciolepsis
5: Malaria (mosquitoes), Diarrhoea (housflies)

Webber, 2005
Expected improvements when installing a water supply

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Water improvement required</th>
<th>Possible reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Skin sepsis and ulcers</td>
<td>Increase water quantity</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>Conjunctivitis</td>
<td>Increase water quantity</td>
<td>70</td>
</tr>
<tr>
<td>1</td>
<td>Trachoma</td>
<td>Increase water quantity</td>
<td>60</td>
</tr>
<tr>
<td>1</td>
<td>Scabies</td>
<td>Increase water quantity</td>
<td>80</td>
</tr>
<tr>
<td>1</td>
<td>Yaws</td>
<td>Increase water quantity</td>
<td>70</td>
</tr>
<tr>
<td>1</td>
<td>Leprosy</td>
<td>Increase water quantity</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>Tinea</td>
<td>Increase water quantity</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>Louse-borne fevers</td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>Flea-borne diseases (including plague)</td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>Enteric viruses (including hepatitis A and polio)</td>
<td>Increase water quantity</td>
<td>10?</td>
</tr>
<tr>
<td>2</td>
<td><em>Enterobius</em></td>
<td>Increase water quantity</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td><em>Hymenolepis</em></td>
<td>Increase water quantity</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td><em>Amoebiasis</em></td>
<td>Increase water quantity</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td><em>Trichuris</em></td>
<td>Increase water quantity</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td><em>Giardia</em></td>
<td>Increase water quantity</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td><em>Shigella</em></td>
<td>Improve water quality</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Typhoid</td>
<td>Improve water quality</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Other Salmonellae</td>
<td>Improve water quality</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td><em>Campylobacter</em></td>
<td>Improve water quality</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Non-specific diarrhoeal diseases</td>
<td>Improve water quality</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td><strong>Cholera</strong></td>
<td>Improve water quality</td>
<td><strong>90</strong></td>
</tr>
<tr>
<td>2</td>
<td>Leptospirosis</td>
<td>Improve water quality</td>
<td>80</td>
</tr>
<tr>
<td>3a</td>
<td><em>Ascaris</em></td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>3a</td>
<td>Hydatid</td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>3a</td>
<td><em>Toxocara</em></td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>3a</td>
<td><em>Toxoplasmosis</em></td>
<td>Increase water quantity</td>
<td>40</td>
</tr>
<tr>
<td>4a</td>
<td>Guinea worm</td>
<td>Reduce water contact</td>
<td>100</td>
</tr>
<tr>
<td>4b</td>
<td>Schistosomiasis</td>
<td>Reduce water contact</td>
<td>60</td>
</tr>
<tr>
<td>5a</td>
<td>Malaria</td>
<td>Water piped to site of use and</td>
<td>10</td>
</tr>
<tr>
<td>5a</td>
<td>Filariasis</td>
<td>maintenance of water supplies</td>
<td>10</td>
</tr>
<tr>
<td>5a</td>
<td><em>Arboviruses</em></td>
<td></td>
<td>10?</td>
</tr>
<tr>
<td>5b</td>
<td>Onchocerciasis</td>
<td>Water piped to site of use</td>
<td>20?</td>
</tr>
<tr>
<td>5b</td>
<td>Gambian trypanosomiasis</td>
<td></td>
<td>80</td>
</tr>
</tbody>
</table>

Webber, 2005
Expected improvements from installation of Sanitation

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Through reduced contamination of</th>
<th>Possible reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trachoma</td>
<td>The environment; flies (group 5c)</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>Enteric viruses (including hepatitis A)</td>
<td>Vegetables</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td><em>Hymenolepis</em></td>
<td>Food and water</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>Amoebiasis</td>
<td>Vegetables</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td><em>Trichuris</em></td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td>Giardia</td>
<td>Food and water</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td><em>Shigella</em></td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td>Typhoid</td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td>Other Salmonellae</td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td><em>Campylobacter</em></td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td>Non-specific diarrhoeal diseases</td>
<td>Food and water</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td>Cholera</td>
<td>Food and water</td>
<td>+++</td>
</tr>
<tr>
<td>3a</td>
<td><em>Ascaris</em></td>
<td>Soil</td>
<td>+ + +</td>
</tr>
<tr>
<td>3a</td>
<td>Hookworm</td>
<td>Soil</td>
<td>+ + +</td>
</tr>
<tr>
<td>3a</td>
<td><em>Strongyloides</em></td>
<td>Soil</td>
<td>+ + +</td>
</tr>
<tr>
<td>3b</td>
<td><em>Taenia</em></td>
<td>Soil</td>
<td>++</td>
</tr>
<tr>
<td>4b</td>
<td>Schistosomiasis</td>
<td>Soil</td>
<td>++</td>
</tr>
<tr>
<td>4c</td>
<td><em>Fasciolopsis</em></td>
<td>Water</td>
<td>+</td>
</tr>
<tr>
<td>4c</td>
<td><em>Opisthorchis</em></td>
<td>Water</td>
<td>+</td>
</tr>
<tr>
<td>4c</td>
<td><em>Paragonimus</em></td>
<td>Water</td>
<td>+</td>
</tr>
<tr>
<td>4c</td>
<td><em>Diphyllobothrium</em></td>
<td>Water</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>Housefly-transmitted diseases</td>
<td>The environment; flies</td>
<td>±±</td>
</tr>
<tr>
<td>5</td>
<td>Filariasis</td>
<td><em>Culex quinquefasciatus</em> breeding</td>
<td>+</td>
</tr>
</tbody>
</table>

Webber, 2005
Control of the Environment

Food Protection & Safe Food

Key Messages

- Cook foods thoroughly
- Store foods carefully
- Reheat foods thoroughly
- Avoid contacts between raw and cooked foods
- Wash hands repeatedly during food preparation
A child-vendor of food, in Haiti 2010.
A roadside makeshift kitchen, beside a refugee camp in Pakistan
Safe Water

- Protection of water sources
- Treatment of water sources: Chlorination, filtration
- Safe Water collection and storage practices
  - Narrow-mouthed vessels
  - Chlorination
- Household Water Treatment
  - Boiling
  - Chlorination
  - Solar disinfection (UV light and heat)
  - UV disinfection with lamp
  - Chemical
Years of neglect means that clean water is scarce in Zimbabwe. Raw sewage flows through the streets.

People collected rain water from a roadside drainage system in Harare.
Collection of drinking water from bore hole for testing
Collection of water from a dug-well used for household purposes
Collection of water from a dug-well used for drinking
Collection of tap water from a kitchen of a school
Safe Sanitation

 Improvement of Sanitation

 - Connection to public sewer
 - Connection to septic tank
 - Pour-flush latrines
 - Pit-latrines
 - Ventilated improved latrines

 Replace bucket-latrines and trenches with improved latrines.
A toilet in a poor neighbourhood, Pakistan
In Pakistan
Surveillance

- Provides useful background information to:
  - Predict outbreaks
  - Help epidemiological confirmation of an outbreak when a cluster of cases is discovered or when there is a sudden increase in cases or deaths from AWD.

- Information should contain name, address, age, sex, date of onset, initial clinical assessment, evolution of illness, treatment received.

- Tools: Data Collection Forms
  Databases for archiving data (Excel, EpilInfo)
  Protocol for Case-Control Study
Vaccination

**Parenteral vaccination**: Not recommended.

**Oral vaccination**: Effectiveness varies between 90%-40%.

**Endemic areas**: With other prevention and control strategies. Should be targeted at high-risk areas and population groups. Periodic mass-vaccinations may be an option.

**During Outbreaks**: Must not disturb other prevention/control activities.

  **Pre-emptive**: May be considered to help prevent potential outbreaks or spread of the current outbreak to new areas.

  **Reactive**: May be extremely difficult, due to logistical and operational issues.

Evidence on the feasibility and impact is lacking.
Mass Chemoprophylaxis: Not recommended.

It usually takes longer to organize distribution of the drug than the infection to spread.

The effect of the drug persists for only a day or two, after which infection can occur.

To prevent infection, the entire population would need to be treated simultaneously and then isolated.

Adverse effects, increasing microbial resistance.

Provides false sense of security

It may be difficult to persuade asymptomatic persons to take drugs.
External conditions
- gatherings
- natural disasters
- population displacement

Climatic conditions
- rainy seasons
- floods
- droughts

Living conditions
- over-crowding
- lack of sanitation
- lack of pure water supply
- unsafe food

Cultural practice

Ingredients for cholera outbreaks
Outbreak Detection

 Alerts, due to:

- A sudden occurrence of the disease
- A persistent increase in reported cases
- A sudden increase in number of cases
- An abnormal number of deaths.

Rapid Verification and Response Team

- Physician
- Microbiologist
- Epidemiologist
- Water & sanitation expert
Outbreak Confirmation

Case definition

- **Suspected:**
  - When, in an area where the disease is not known to be present, a patient aged 5 years or more develops severe dehydration or dies from AWD.
  - When, in an area where there is an outbreak, a patient aged 5 years or more, develops AWD with or without vomiting.

- **Confirmed**
  - Isolation of *V. cholera* from any patient with diarrhea.
Investigation of the cause of the outbreak

Once the cholera outbreak is clinically verified, investigate the potential vehicles of transmission.

- Drinking water
  Contaminated at source/during transport/storage, ice made with contaminated water
- Food, contaminated during or after cooking
- Seafood
- Fruits/vegetables
Organization of Outbreak Response

❖ Cholera Coordination Committee

❖ First steps after confirmation of cholera outbreak

- Convene CCC
- Make inventory of essential supplies
- Conduct training, if necessary
- Set up temporary DTCs, if necessary
- Inform public, neighbouring regions/district, (media)
- Collect, and analyse data on cases, deaths, and control activities; document the outbreak; adapt interventions
Implement control measures

- Disinfection of water sources,
- Food safety measures,
- Conduct health education campaigns,
- Ask for additional help,
- Monitor and evaluate control measures.
Managing Information

- Avoid rumours
- Choose a spokesperson
- Evaluate reporting in the media
  - Informative
  - Appropriate
DTC in Cholera Epidemic

Why DTC?

- A large number of patients still die of cholera each year, particularly during epidemics.
- The rate and volume of fluid loss in cholera can threaten life within hours of onset.
- Cholera deaths only occur due to lack of treatment or inadequate treatment; and can be easily averted by prompt and effective rehydration therapy.
- Deaths always highest at the beginning of epidemics and associated with areas that have communication difficulties.
DTC in Cholera Epidemic

Access to treatment facilities is often the major problem for cholera patients requiring medical care, particularly in *remote areas*.

*Temporary treatment centers* particularly in remote areas - effective in averting deaths during cholera epidemics.

*Aim* - *to provide quick access to treatment* and ensure prevention of deaths.
Setting Up DTC

Why is planning required to set up makeshift treatment centre?

- The expected *effectiveness* of a makeshift treatment centers will depend on sound planning and on efficient running of the centre.

- In emergencies, it could be *difficult* to address these issues thoroughly.

- *Pre-designed guidelines* could be extremely useful.

- Planners can *adapt it* according to the need.
Health Education Campaign during Outbreaks

Key messages

 dez In case of diarrhoea, come to the health care facilities as soon as possible.
 dez Start drinking ORS at home and during travel to the health care facilities.
 dez Wash your hands before cooking, before eating, and after using toilets.
 dez Cook your food, eat freshly prepared food.
 dez Drink safe water.
Attack rate

(Number of cases/population at risk) in a given period of time.

When high, indicates-

- Common source of infection
- The area is very crowded (refugee camps)
Case Fatality Rate

(number of deaths/number of cases) X 100, in a given period of time.

If too high, indicates-

- Poor case management
- Lack in supplies
- Health care facilities are overwhelmed
- Patients arriving too late at DTCs
- Bias in surveillance
Case management

Assessment of patient
Rehydration – I.V. / ORS
Maintain hydration
Frequent re-assessments and monitoring progress
Nutrition (particularly infants and young children)
Antibiotics
Health education

Complications
Pulmonary oedema if too much IV fluid
Acute Renal failure if dehydration prolonged
Hypoglycaemia and hypokalaemia in malnourished children

Check for co-morbidities
Hospital management success during an extreme diarrheal disease outbreak: Experience at ICDDR,B Hospital 2007
Coping with Floods
Diarrheal Diseases Outbreak

► One of the worst monsoon season in South Asia in recent years caused flooding
► Contaminated water supply
► Over 14 million people displaced
► Unprecedented surge in the number of patient visits at the Dhaka Hospital
Dhaka Hospital, ICDDR,B
Weekly Patient Visits
2006 & 2007
Some Findings

- 43,359 patients (July - September)
- 34% had culture confirmed cholera
- 84% of the cholera patients had severe dehydration
- 93% of the patients required intravenous fluids for their management
Adaptive Crisis Management

Tents constructed overnight to house increased patient load

Cots constructed and setup in preparation for patient overload
Achievements

- The hospital saved an estimated 13,000 lives during this period.

- None of the patients died due to dehydrating diarrhoea alone.
### Comparison with Goma, Zaire 1994

<table>
<thead>
<tr>
<th>Outbreak Location</th>
<th>Operator</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goma, 1994</td>
<td>Rwandan Staff</td>
<td>14.5%</td>
</tr>
<tr>
<td>Goma, 1994</td>
<td>Other groups</td>
<td>2.3%</td>
</tr>
<tr>
<td>Goma, 1994</td>
<td>ICDDR,B + Other groups</td>
<td>0.6%</td>
</tr>
<tr>
<td>Dhaka, 2007</td>
<td>ICDDR,B</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Problems with Goma Centres:** No use of ORS,
Long lines of patients waiting for treatment,
Slow rehydration; use of inappropriate sized needles,
Untrained/ inexperienced staff.
Minimizing deaths in cholera patients

- Early Home Management
  Using ORS right from the onset

- Early Referral to the nearest
  Health Centre

Health Education / Social Mobilization

- Appropriate Case Management